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June 12, 2000

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JUN 12 2000
PATENT & TRADEMARK OFFICE

Assistant Commissioner for Patents
Washington, D.C. 20231

Attention: Box PCT - DESIGNATED/ELECTED OFFICE (DO/EO/US)

FORM PTO-1390 (REV 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 31583-160474 RK
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
INTERNATIONAL APPLICATION NO. PCT/DE98/03297	INTERNATIONAL FILING DATE November 3, 1998	PRIORITY DATES CLAIMED: December 10, 1997
TITLE OF INVENTION - see attached pages -		
APPLICANT(S) FOR DO/EO/US - see attached pages -		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. X This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. X This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(l).

- See attached pages for additional data -

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Washington, D.C. 20231

Attorney Docket: 31583-160474 RK

Attention: PCT-DO/US

Re: International Application PCT/DE98/03297 filed November 3, 1998
Priority Claimed: German Patent Application 197 54 891.1 filed November 3, 1997

Inventor: **Vladimir POTAPOV**
Robert-Koch-Strasse 23, D-66386 St. Ingbert, Germany
Citizenship: GERMANY

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Inventor: **Thomas HAHN**
Rhodter Strasse 8, D-66386 St. Ingbert, Germany
Citizenship: GERMANY

Title: ULTRASONIC TRANSDUCER*

***Please note this is the title appearing on the first page of the translation of the International Application and in the Declaration and Assignment. This title is different from the translated title appearing at line 54 on the cover sheet of WO 99/30313.**

Sir:

Submitted herewith, as the first submission, are the following for the purposes of entering the national stage for the USA under 35 U.S.C. 371(c), **immediate national examination under 35 U.S.C. 371(f) being requested.**

- International Application No. PCT/DE98/03297 as originally filed and published as WO 99/30313 with English-language international search report issued by the European Patent Office.

- Translation of PCT/DE98/03297.

- International Preliminary Examination Report (IPER) and annexed pages.

- Translation of International Preliminary Examination Report and annexed pages.

- Preliminary Amendment to eliminate multiple claim dependency.

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NOTE: For purposes of U.S. examination, please insert the Amended Sheets (Pages 2, 3, 3a, 8 and 16-18 annexed to the translation of the International Preliminary Examination Report into the translation of the original application so that the application for examination comprises the following pages of the English translation:

- Original page 1;
- Altered pages 2, 3 and 3a;
- Original pages 4, 5, 6, 7, 8 and 9;
- Altered pages 10, 11, 12 and 13 (containing claims 1-16); and
- Original page 14 (Abstract).

Official Fees:

Filing fee enclosed: $840.00

Should no remittance be attached, or should a greater or lesser fee be required, please charge or credit our Account No. 22-0261.

Respectfully submitted,

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RK/trt

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re PATENT APPLICATION of

Applicants	:	Vladimir POTAPOV et al.	
Int'l Appln. No.	:	PCT/DE98/03297	
Int'l Filing Date	:	November 3, 1998	
For	:	ULTRASONIC TRANSDUCER	**PRELIMINARY AMENDMENT**
Attorney Docket	:	31583-160474 RK	
			June 12, 2000

Assistant Commissioner for Patents
Washington, D.C. 20231

Attention: PCT DO/EO/US

Sir:

Prior to examination and calculation of the filing fee for this application, please amend the claims of the international preliminary examination report as follows:

Claim 4, lines 1-2, change "one of the claims 1 to 3" to –claim 1–.

Claim 5, lines 1-2, change "one of the claims 1 to 4" to –claim 1–.

Claim 7, lines 1-2, change "one of the claims 1 to 6" to –claim 1–.

Claim 8, lines 1-2, change "one of the claims 1 to 7" to –claim 1–.

Claim 10, lines 1-2, change "one of the claims 1 to 9" to –claim 1–.

Claim 12, lines 1-2, change "one of the claims 1 to 10" to –Claim 1–.

Claim 13, lines 1-2, change "one of the claims 1 to 12" to –Claim 1–.

Claim 14, lines 1-2, change "one of the claims 1 to 13" to –Claim 1–.

REMARKS

The claims have been amended to eliminate multiple claim dependency.

Respectfully submitted,

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Ultrasonic Transducer

The present invention relates to an ultrasonic transducer for use as a transmitter and receiver in pulse-echo applications, in which air is the transmission medium for the sound wave.

A particular field of application for the ultrasonic transducer as a sensor is the motor vehicle sector. In this field there is a need for transducers for detecting objects in the interior of the vehicle, for example to control the triggering of an airbag during an accident.

There are already numerous ultrasonic transducers for such applications on the market. The bending vibration of a membrane has proven to be an especially effective mode of transducer vibration. In order to generate vibration, a round piezoceramic disk is glued in the center on the rear side of a membrane. By applying an electric field, the ceramic is excited to radial vibrations. Stiff adhesive bonding to the membrane yields a bending vibration of the

whole system. In addition, a piece of foamed material for dampening the vibration is provided on the rear side of membrane.
The parameters of the ultrasonic vibration are determined by the elastic and other mechanical properties of the overall system. The elastic properties of the employed materials and the geometric dimensions of the employed components influence the resonance frequency, the aperture angle of the sound lobe, the quality Q of the vibration and the sensitivity of the sensor.
A multiplicity of influential factors that influence each other therefore determines the physical properties of a transducer.

In the above application for controlling airbag triggering during an accident, transducer properties are required that have never been fulfilled in this manner by any of the known transducers. The transducers available on the market all have one or more of the following drawbacks, thus for example too little sensitivity, too small a sound emission aperture angle, no closed form of encasement, insufficient resistance to outside mechanical influences, too high a

mechanical quality Q. Furthermore, they are often too complicated in operation and therefore too difficult to produce.

Therefore, the object of the present invention is to provide an ultrasonic transducer and a process for its fabrication, which has great sensitivity while having a low quality Q as possible and having a large aperture angle. Moreover, it should be possible to execute the transducer in a robust, sturdy encasement and produce it in large piece numbers.

This object is solved with the ultrasonic transducer and the process according to the features of claims 1 and 15. Advantageous embodiments of the ultrasonic transducer and the process for its fabrication are the subject matter of the subclaims.

A key element of the present invention is that an ultrasonic transducer is proposed in which a membrane is disposed in a holding means and a piezoelectric disk is placed on a main surface of the rear side of the membrane. The diameter of the piezoelectric disk is between 60% and 85% of the diameter of the membrane. A first substance is foamed onto the main surface of the rear side of the membrane. Foaming on this substance make it possible to obtain particularly advantageous transducer properties with regard to sensitivity and mechanical quality Q. With the foamed on substance, the described relationship of the diameter of the piezoceramic to the diameter of the membrane yields a large sound emission aperture angle.

The holding means of the ultrasonic transducer which simultaneously forms the encasement can be inexpensively fabricated with the membrane in one piece of one material, for example aluminium or an aluminium alloy (e.g. AlCuMgPb). A holding means that forms with the membrane a pot-shaped structure permits providing a robust transducer sufficiently resistant to outside mechanical influences. The transducer can be fabricated with a simple process, for example an extrusion process, and fulfills therefore the

requirements of inexpensive fabrication in high piece numbers.

In particular, the thickness and the diameter of the ceramic, the thickness and the diameter of the membrane and the overall height of the aluminium encasement essentially influence the properties of the transducer. Thus the center frequency f of the ultrasonic transducer is proportional to the ratio of the square membrane diameter D_M^2 to the membrane thickness d_m. On the other hand, the ceramic thickness d_K is proportional to the center frequency f. The relationship depends on the respective design. Moreover, the sensitivity and the related mechanical quality Q of the vibration can be influenced by the material on the rear side of the ceramic (first substance).

A special ultrasonic transducer for the application of object detection in the interior of a motor vehicle, for example for controlling the triggering of airbags during an accident, operates at a center frequency of 70 kHz. At this frequency, the aperture angle of the 6dB sound lobe should be as large as possible. Such a system requires that all the essential objects with their different surface structure and materials reflect a detectable echo signal in the direction of the transducer. The sensitivity of the transducer has to, therefore, be as great as possible.

An element of the present invention is that a transducer having a membrane diameter of 8.85 ± 0.02 mm, membrane thickness of 0.83 ± 0.02 mm and a ceramic thickness of 0.26 ± 0.01 mm has proven especially advantageous for this application.
Furthermore, a cyclindrical holding means having a wall thickness of at least 2.85mm and a height of, for example, 6.83 mm is employed with such a transducer.

A smaller or greater height of the holding means is, of course, also possible.

The developed sensor fits in an existing occupation detection system in a motor vehicle system without any further changes to the triggering electronics.

The first substance foamed on the rear side of the membrane is preferably made of an open-cell, soft material, for example polyurethane foam or silicon foam.
Especially advantageous transducer properties are obtained with polyurethane foam having a strain hardness (DIN 53577) of < 9kPa and an acoustical loss factor (DIN 53426) of < 1.0.

In a particular preferred embodiment, a piezoceramic having a relative dielectric constant of > 2500, a radial electromechanic coupling factor of > 0.5 and a mechanical quality Q of < 300 is used as the piezoelectric disk.

In fabricating the invented ultrasonic transducer, first a pot-shaped holding means of aluminium or an aluminium alloy, the bottom of which forms the membrane, is made by means of an extrusion process. A piezoelectric disk is glued onto the rear side of the membrane in order to produce a mechanical and an electric contact to the membrane. One end of a thin wire is soldered onto the piezoelectric disk. Finally, a first substance is foamed onto the rear side of the

membrane in the pot-shaped holding means in such a manner that the membrane and the piezoelectric disk are completely covered by the substance.

The invented ultrasonic transducer is, of course, also excellently suited for other air-ultrasonic applications with similar requirements of the essential transducer properties, for example, for distance measurements or position detection systems. Due to the wide sound lobe, the sensor is particularly suited for areal surveillance.

The present invention is made more apparent in the following using a preferred embodiment and the accompanying drawings, in which

Fig. 1 shows a cross section of an example of an invented transducer,

Fig. 2 shows a rear view of the transducer of fig. 1 without the first substance (4) and the second substance (5),

Fig. 3 shows a rear view of the transducer of fig. 1 completely, and

Fig. 4 shows a front view of the transducer of fig. 1.

A preferred embodiment is now described with reference to figs. 1 and 2.

Fig. 1 shows a cross section of a preferred embodiment of the transducer. The transducer comprises a cylindrical aluminium encasement (1). The bottom of the encasement forms an aluminium membrane (2). The aluminium encasement of the transducer is fabricated as a turned part. A piezoceramic disk (3), for example made of a PZT-5H ceramic, is concentrically glued into the aluminium pot (on the rear side of the membrane (2)) using a thin liquid adhesive with pressure. One electrode of the ceramic, which is glued on the membrane surface, has electric contact via the membrane to the aluminium encasement (1). Mass-contacting is ensured by a copper pin (6) driven into the aluminium encasement. If producing large piece numbers, another process can be selected for mass-contacting. The copper pin is connected to a thin wire (8) with a cable (10) that connects the transducer to the triggering electronics. The other electrode of the ceramic (3) is connected to another thin wire (9) via a soldering point (7) at the edge of the ceramic. Placing the soldering point (7) at the edge of the ceramic minimizes the influence of vibration properties of the system. The wire (9) between the ceramic electrode and cable (10) has to be very light in order to avoid other influencing factors on the vibration properties of the system.

Fig. 2 shows a rear view of the sensor with the aluminium encasement (1), aluminium membrane (2), glued on ceramic disk (3), soldering point (7) and mass-contacting (6).

The selected membrane diameter yields the desired aperture angle (here: >45° with a lateral 3dB drop in sound pressure; >55° with a lateral 6dB drop in sound pressure and is tuned to the overall vibration system.

in order to effectively generate the bending vibration. In the exemplary system, the total height of the encasement,

including the thickness and the diameter of the ceramic disk were optimized with regard to the vibration behavior of the system. The thickness of the ceramic has less influence on the vibration behavior than the diameter.

In this example, the components of the ultrasonic transducer (sensor) have the following dimensions:

Thickness of the wall of the encasement d_G:	2.85 mm
Height of the wall of the encasement h_G:	6.83 mm
Diameter of the encasement D_G:	14.55 mm
Diameter of the membrane D_M:	8.85 mm
Thickness of the membrane d_M:	0.83 mm
Diameter of the ceramic disk D_K:	6.75 mm
Thickness of the ceramic thickness d_K:	0.26 mm

All the geometric dimensions of the components involved must be adhered to in order to obtain all aspects of an optimized system for the mentioned application.

An essential parameter of the sensor is the mechanical quality Q. The first substance (4) foamed onto the rear side determines the dampening of the membrane vibration. The thickness of the wall of the pot may also play a role. The elastic properties of the first substance (4) influence the resonance behavior only to a small degree and permit, by using materials with different dampening, setting the mechanical quality Q of the transducer.

An additional, second substance (5) applied onto the first substance (4) on the rear side has the purpose to prevent propagation of a sound wave in the direction opposite to the direction of the radiating membrane and is attuned in its influence on the resonance behavior of the whole system. The material of the second substance (5) is a polyurethane and, moreover, fulfills the object of securing the transition between the very light wire that contacts the electrodes and the heavier connection cable.

Fig. 1 shows the degree that the first and second substances (4,5) cover the membrane respectively fill the aluminium encasement. In the embodiment, the distance of the top edge of the second substance (5) to the top edge of the encasement wall (1) is 1.17mm.
Finally, figs. 3 and 4 show another rear view and a front view of the entire ultrasonic transducer.

What Is Claimed Is:

1. An ultrasonic transducer, in particular, for use as a transmitter and a receiver in pulse-echo applications in which a membrane is disposed in a holding means and a piezoelectric disk is placed on a main surface of the rear side of the membrane,
with the diameter of said piezoelectric disk being between 60% and 85% of the diameter of said membrane and a first substance being foamed onto said main surface of said rear side of said membrane.

2. An ultrasonic transducer according to claim 1,
characterized by,
said holding means being made with said membrane as one piece from one material.

3. An ultrasonic transducer according to claim 2,
characterized by,
said material being aluminium or an aluminium alloy.

4. An ultrasonic transducer according to one of the claims 1 to 3,
characterized by,
said holding means with said membrane forming a pot-shaped structure.

5. An ultrasonic transducer according to one of the claims 1 to 4,
characterized by,
in order to generate a center frequency of 70 kHz, the diameter of said membrane is 8.85 ± 0.02 mm, the thickness of said membrane being 0.83 ± 0.02 mm and the thickness of the ceramic being 0.26 ± 0.01 mm.

6. An ultrasonic transducer according to claim 5, characterized by, a cylindrical holding means having a wall thickness of at least 2.85 mm and a height of approximately 6 mm being employed.

7. An ultrasonic transducer according to one of the claims 1 to 6, characterized by, said piezoelectric disk being glued onto said membrane.

8. An ultrasonic transducer according to one of the claims 1 to 7, characterized by, said piezoelectric disk being a piezoceramic.

9. An ultrasonic transducer according to claim 8, characterized by,

said piezoceramic having a relative dielectric constant of > 2500, an electromechanic coupling factor of > 0.5 and a mechanical quality Q of < 300.

10. An ultrasonic transducer according to one of the claims 1 to 9, characterized by, said first substance being composed of a soft, open-cell material.

11. An ultrasonic transducer according to claim 10, characterized by, said first substance being composed of a polyurethane foam or silicon foam.

12. An ultrasonic transducer according to one of the claims 1 to 10,
characterized by,
said first substance being composed of a polyurethane foam having a strain hardness of < 9 kPa and an acoustical loss factor of < 1.0.

13. An ultrasonic transducer according to one of the claims 1 to 12,
characterized by,
a second substance being provided on said first substance.

14. An ultrasonic transducer according to one of the claims 1 to 13,
characterized by,
a first electrode of said piezoelectric disk being connected via said membrane and said holding means with mass, and a second electrode of said piezoelectric disk being contacted via a thin wire soldered to the edge of said disk.

15. A process for fabricating an ultrasonic transducer having the following process steps:
fabrication of a pot-shaped holding means of aluminium or an aluminium alloy, the bottom of which forms a membrane,
gluing on a piezoelectric disk onto the rear side of said membrane in such a manner that a mechanical and an electric contact to said membrane are yielded,
soldering on one end of a thin wire onto said piezoelectric disk,
foaming on a first substance in said holding means on said rear side of said membrane in such a manner that said membrane and said piezoelectric disk are completely covered by said substance.

16. A process according to claim 15, characterized by,

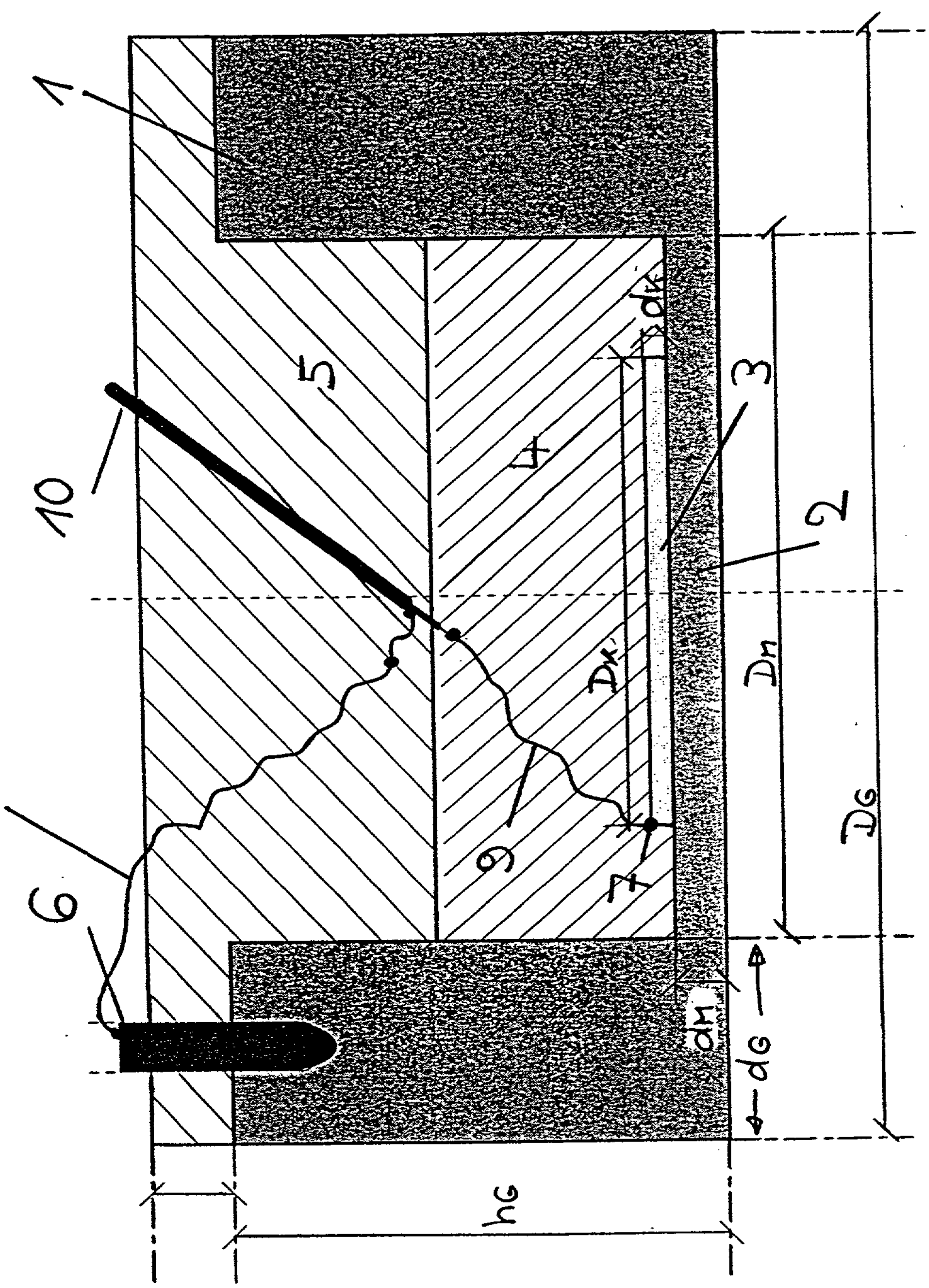
a second substance being applied on said first substance, which is to prevent the propagation of a sound wave in the direction opposite to the desired direction of the radiating membrane.

Abstract

The present invention relates to an ultrasonic transducer, in particular, for use as a transmitter and a receiver in pulse-echo applications, in particular in the motor vehicle sector to object detection inside the interior of vehicles, for example to control the triggering of an air bag triggering during an accident.

The invented ultrasonic transducer is provided with a membrane having a piezoelectric disk disposed on its rear side. The diameter of the piezoelectric disk is between 60% and 85% of the diameter of the membrane. A substance of open-cell, soft material is foamed onto the main surface of said rear side of the membrane. Foaming on this substance can yield especially advantageous transducer properties with regard to sensitivity and mechanical quality Q. If the substance is foamed on, the described relationship between the diameter of the piezoceramic and the diameter of the membrane results in a large sound emission aperture angle.

Fig. 1



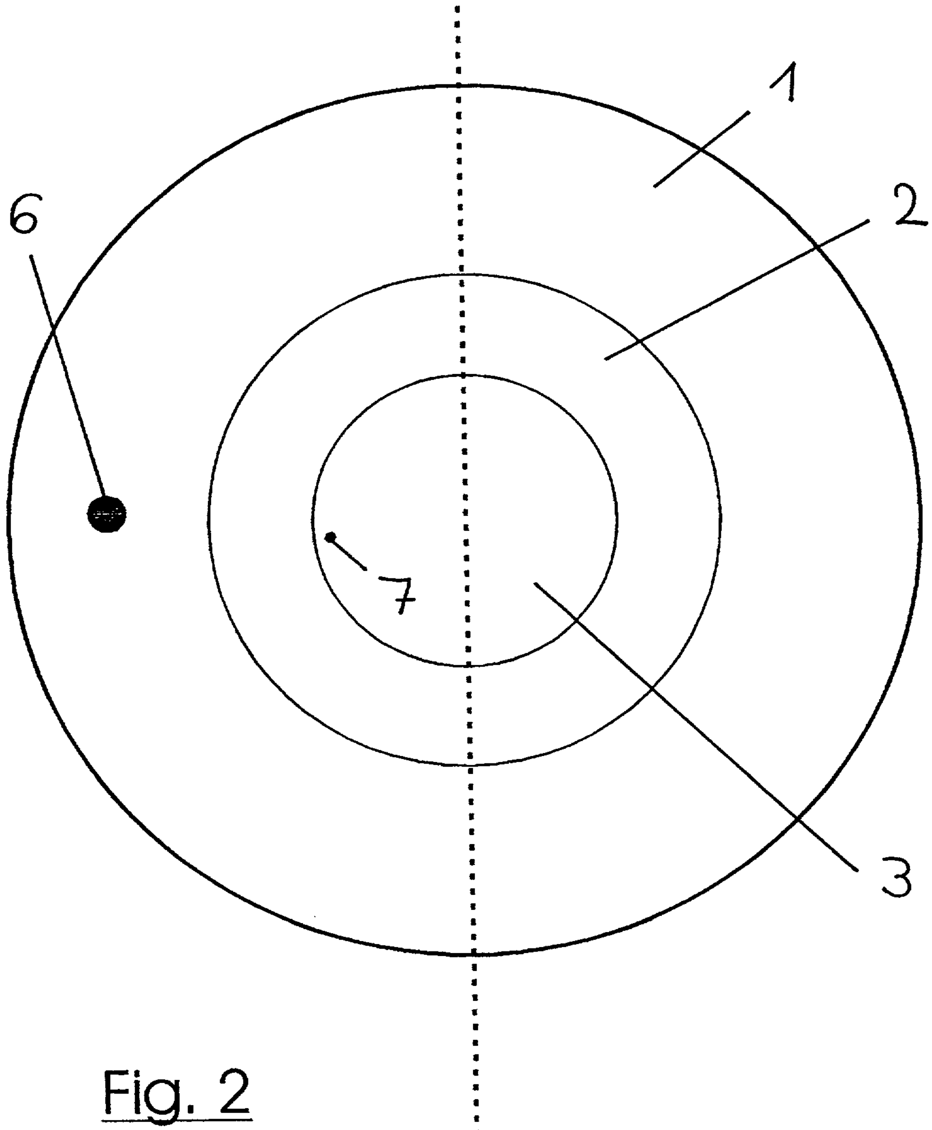


Fig. 2

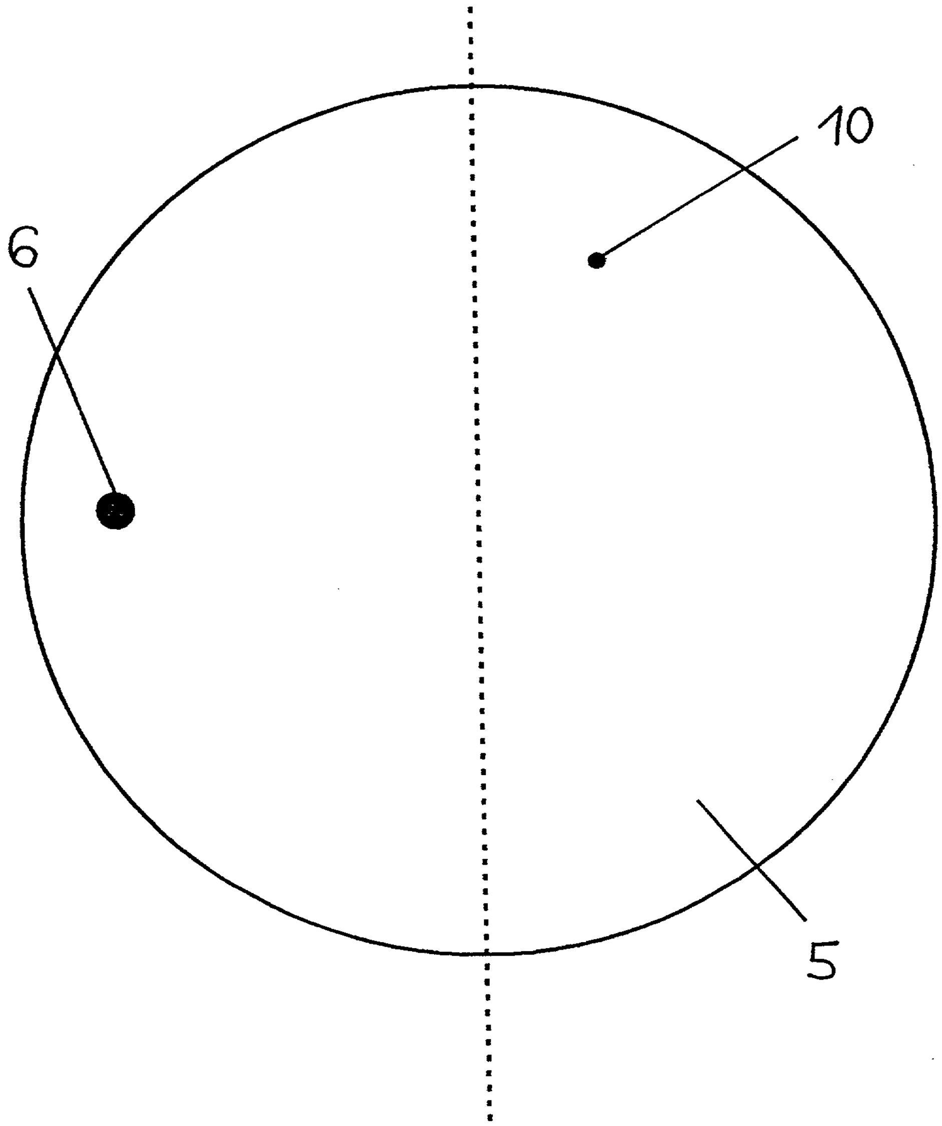


Fig.3

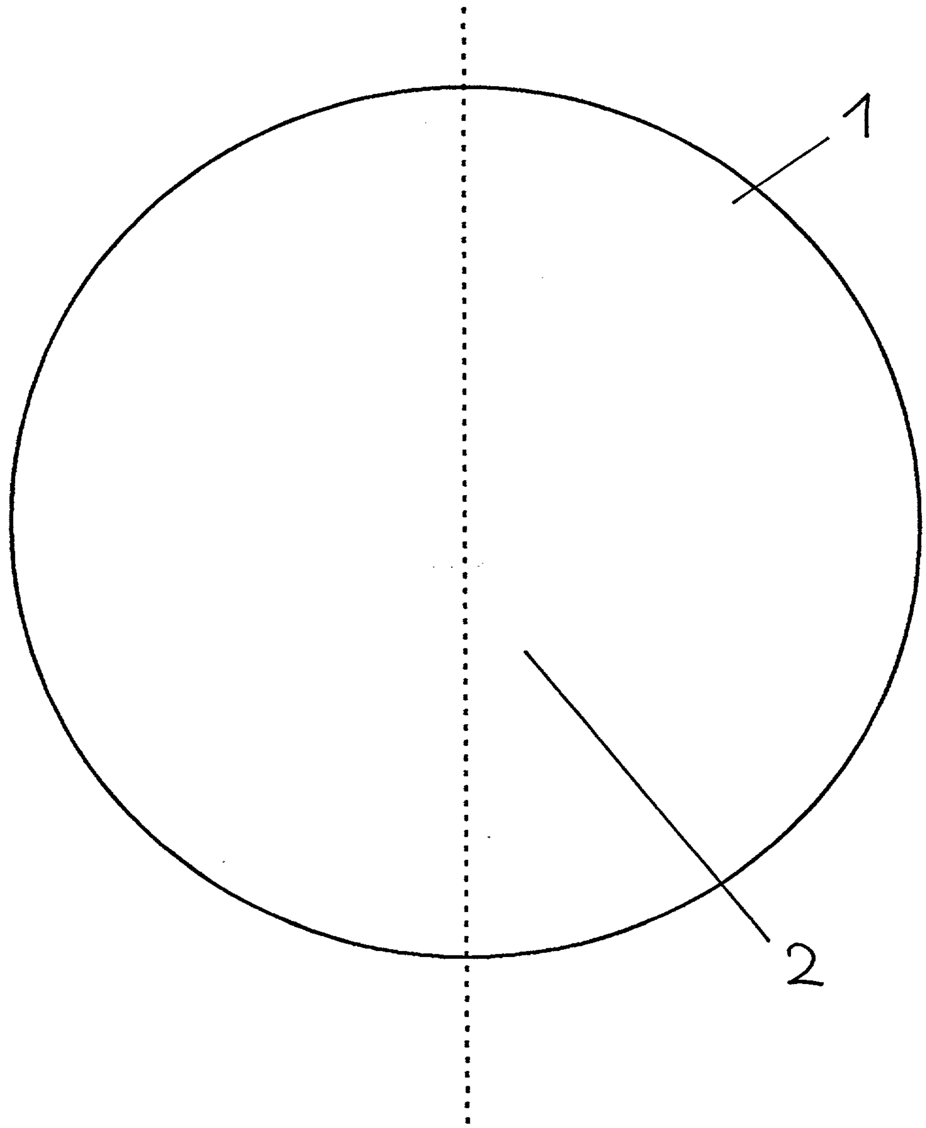


Fig. 4

DECLARATION FOR UNITED STATES PATENT APPLICATION
POWER OF ATTORNEY, DESIGNATION OF CORRESPONDENCE ADDRESS

Attorney Docket
31583-160474 RK

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and that I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled ULTRASONIC TRANSDUCER, the specification of which

[ ] is attached hereto.
[ ] was filed on ________, as Application No. ______________, and was amended on ______________ [if applicable].
[X] was filed under the Patent Cooperation Treaty on November 3, 1998, Serial No. PCT/DE98/03297, the United States of America being designated.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, 120 of any foreign application(s) for patent, utility model, design or inventor's certificate listed below and have also identified below any foreign application(s) for patent, utility model, design or inventor's certificate having a filing date before that of the application(s) on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
Number	Country	Date Filed	Yes	No
197 54 891.1	Germany	December 10, 1997	X	

I hereby appoint the following attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: George H. Spencer (Reg. No. 18,038), Norman N. Kunitz (Reg. No. 20,586), Robert J. Frank (Reg. No. 19,112), Gabor J. Kelemen (Reg. No. 21,016), Robert Kinberg (Reg. No. 26,924), John W. Schneller (Reg. No. 26,031), Ashley J. Wells (Reg. No. 29,847), Allen Wood (Reg. No. 28,134), James R. Burdett (Reg. No. 31,594) Suite 1000, 1201 New York Avenue, N.W., Washington, D.C. 20005-3917, Telephone: (202) 962-4800, Telefax: (202) 962-8300.

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Address all correspondence to VENABLE, P.O. Box 34385, Washington, D.C. 20043-9998.

The undersigned hereby authorizes the U.S. attorneys named herein to accept and follow instructions from the undersigned's assignee, if any, and/or, if the undersigned is not a resident of the United States, the undersigned's domestic attorney, patent attorney or patent agent, as to any action to be taken in the Patent and Trademark Office regarding this application without direct communication between the U.S. attorneys and the undersigned. In the event of a change in the person(s) from whom instructions may be taken, the U.S. attorneys named herein will be so notified by the undersigned.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00

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2-00

Signature: [signature] Date: 15.6. , 2000.
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Signature: Thomas [signature] Date: 23.05. , 2000.
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